Video Bandpass

Luminance    Chrominance
Spectrum      Spectrum

Color
Subcarrier

40  Audio
Subcarrier

FM-Audio
Bandpass

18

Data
Channel     50

30

20

Data
Subcarrier

-2    -1    0    1    2    3    4    5    Freq (MHz)

Figure 1. Spectrum of Standard NTSC Signal with Overlay Data Channel
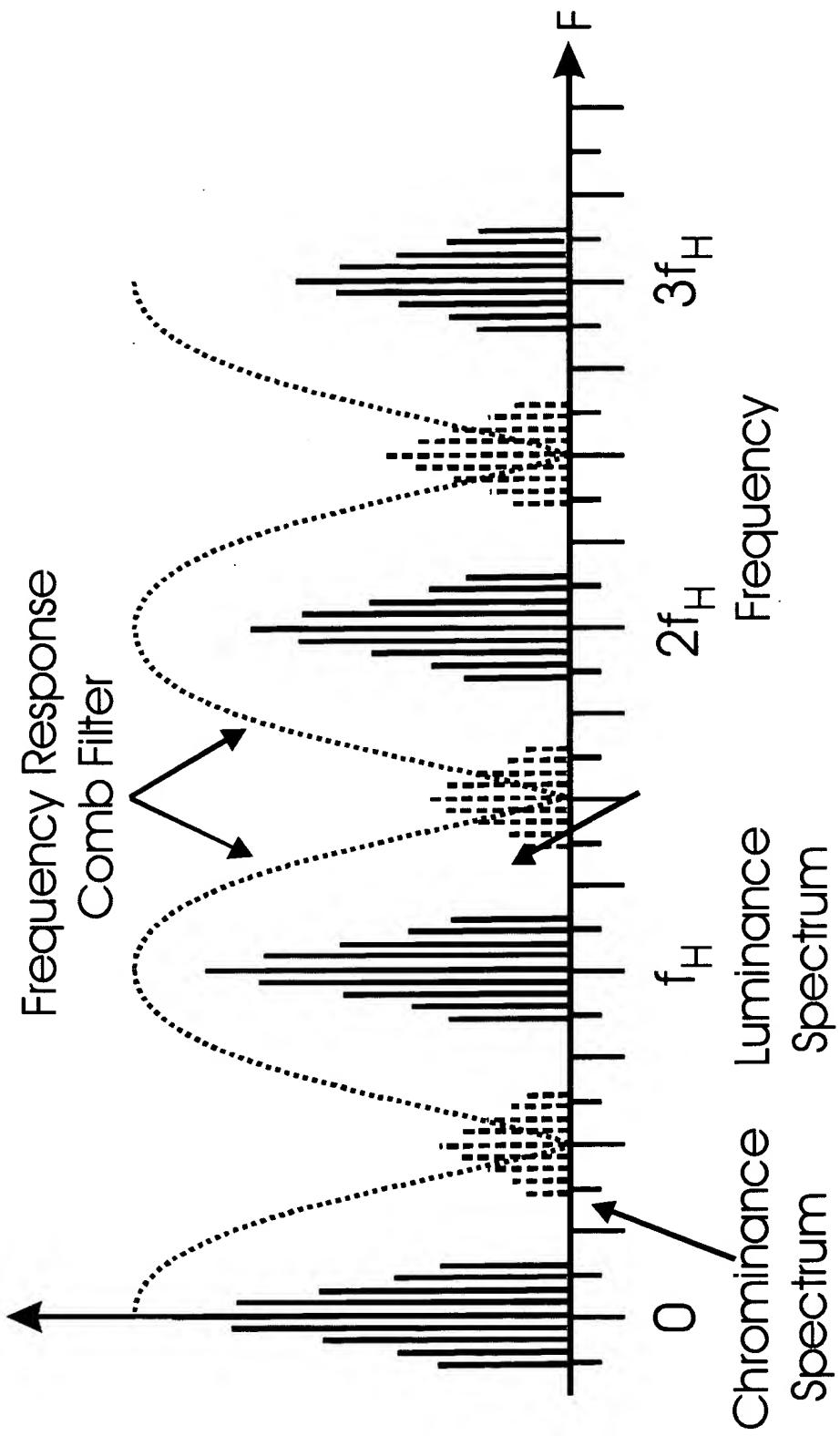
Figure 2. Luminance and Chrominance Spectral Clusters at Multiples of Horizontal Line Frequency and Comb Filter Frequency Response that Passes Luminance Spectrum
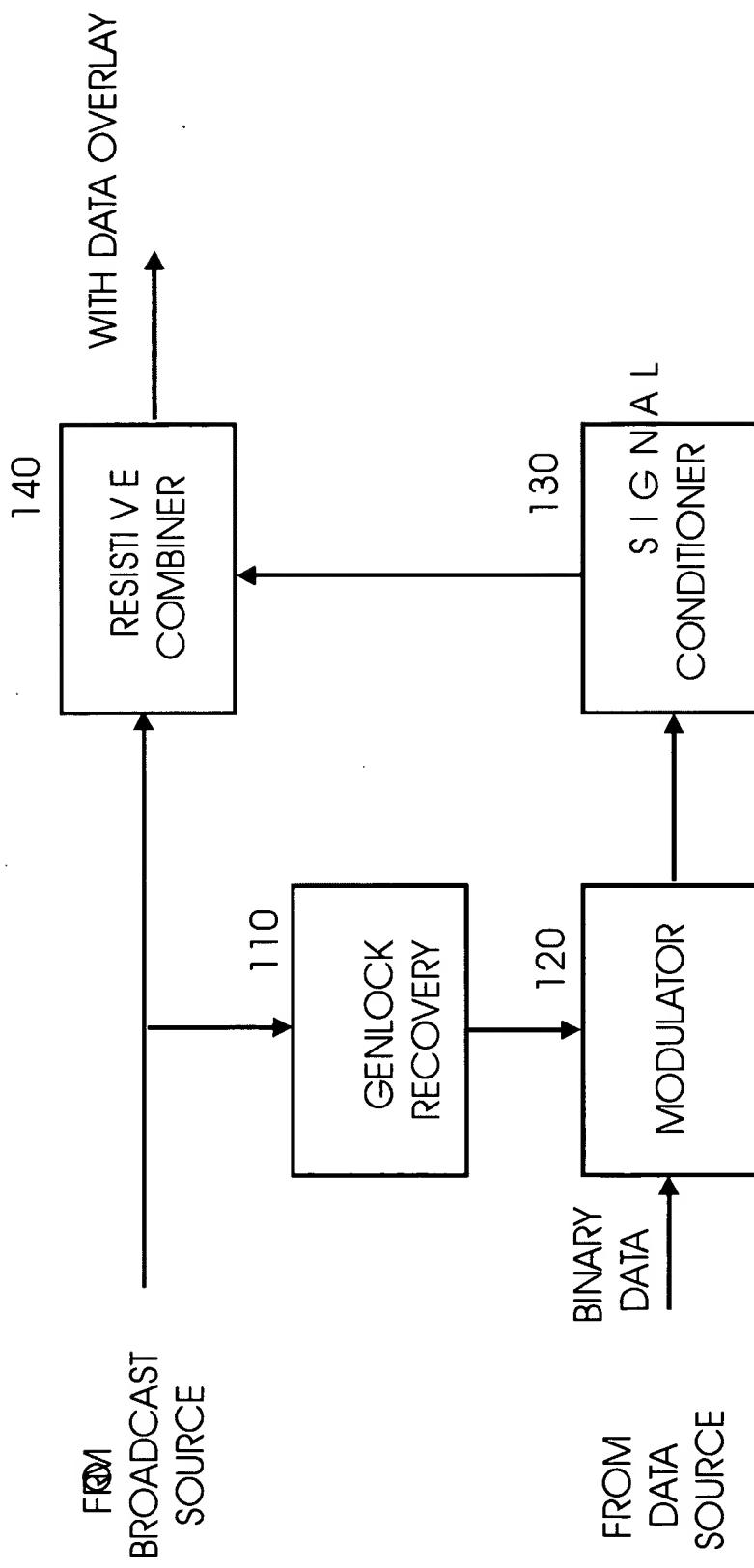
Figure 3 Diagram of Modulator Signal Processing Blocks and Signal Flow at Transmitter
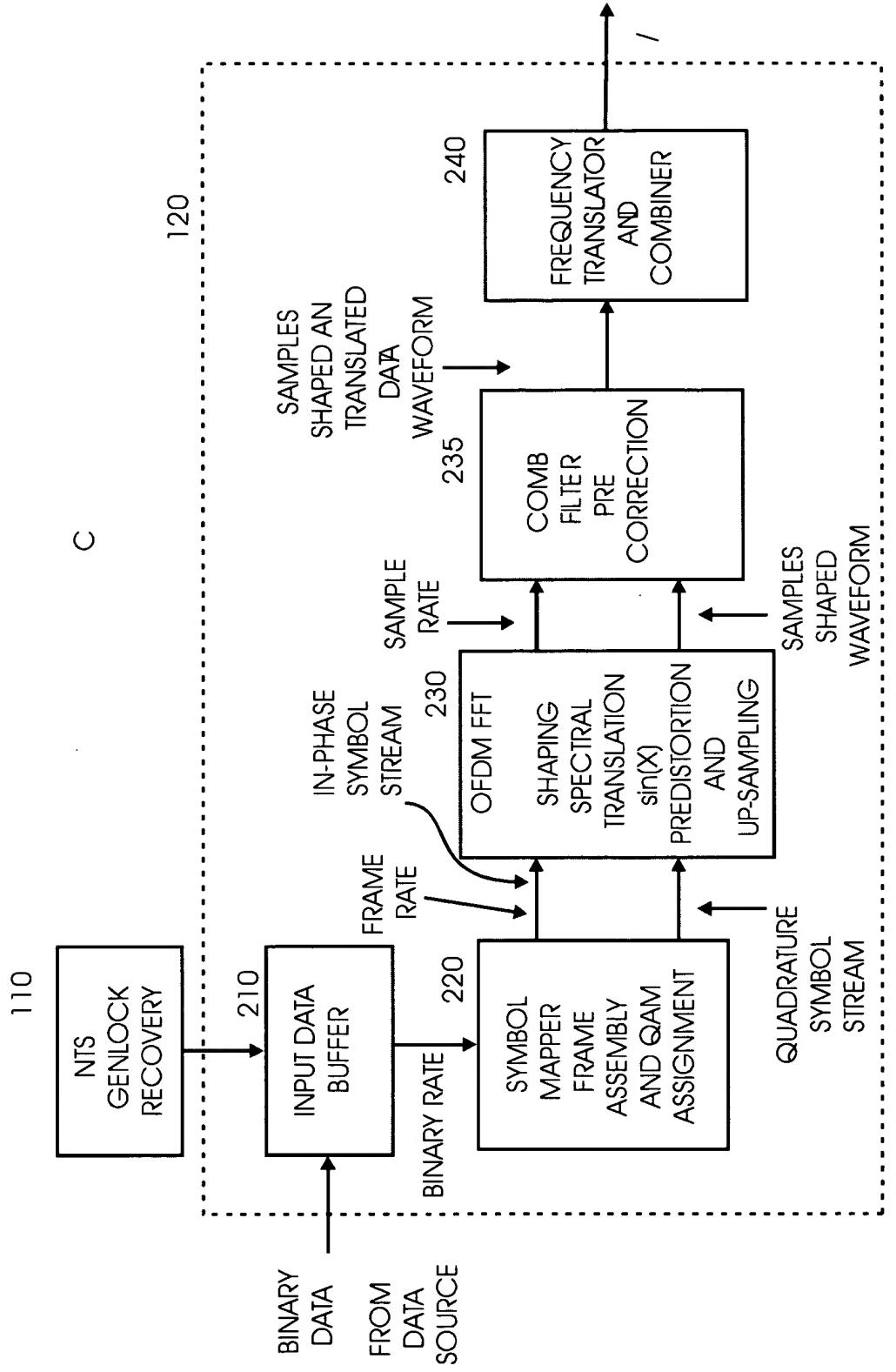
FIGURE 4. DIGITAL DATA MODULATOR
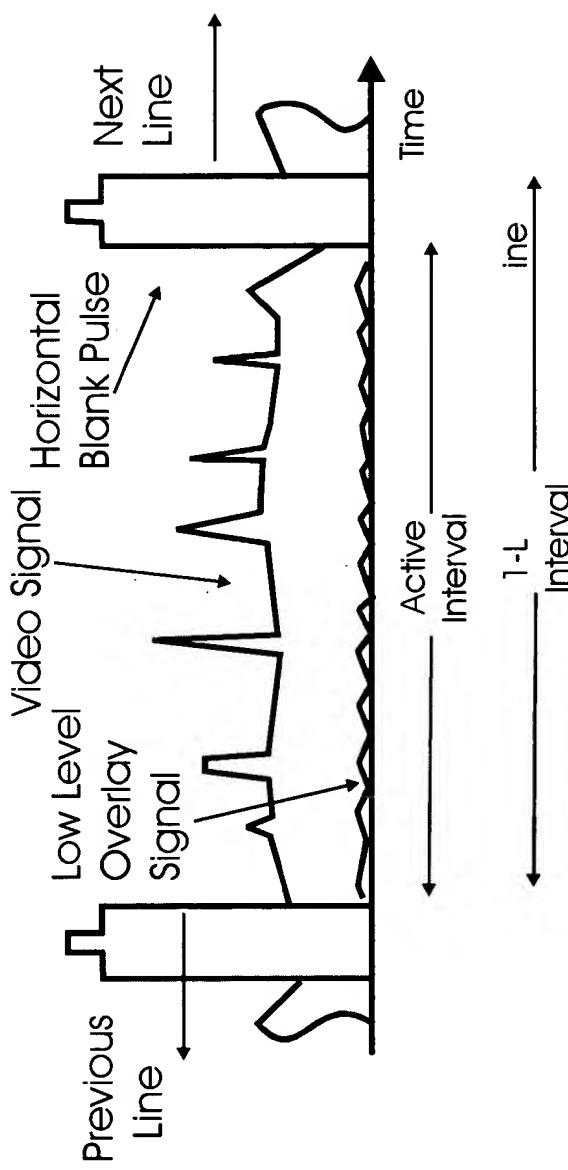
Figure 5. Time Domain Representation of NTSC Horizontal Line Showing Temporal Position of Low Level OFDM Modulated Data

FIGURE "6B" OFDM SPECTRUM

Color
Subcarrier          Audio
                   Subcarrier   FM-Audio
                               Bandpass

Video Bandpass

Luminance   Chrominance
Spectrum    Spectrum

        Data
       Channel

Data
Subcarrier

-2  -1   0   1   2   3   4   5   Freq (MHz)

Expanded View of
OFDM Spectrum
in

Luminance
Spectrum

20 KHz          60 KHz

1.72  1.88  1.94  2.00  2.06  2.12  2.18   Freq (MHz)
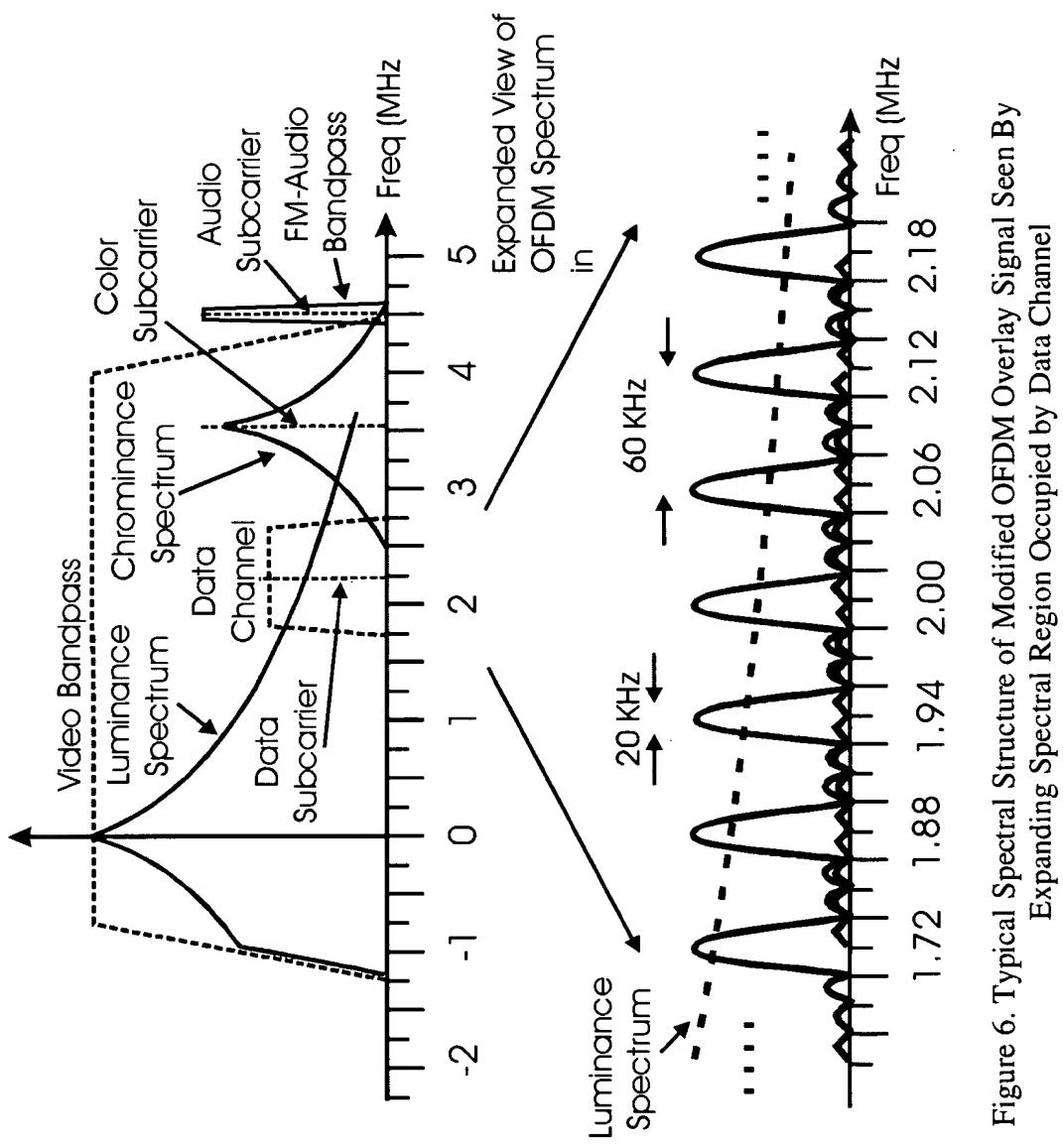
Figure 6. Typical Spectral Structure of Modified OFDM Overlay Signal Seen By
Expanding Spectral Region Occupied by Data Channel
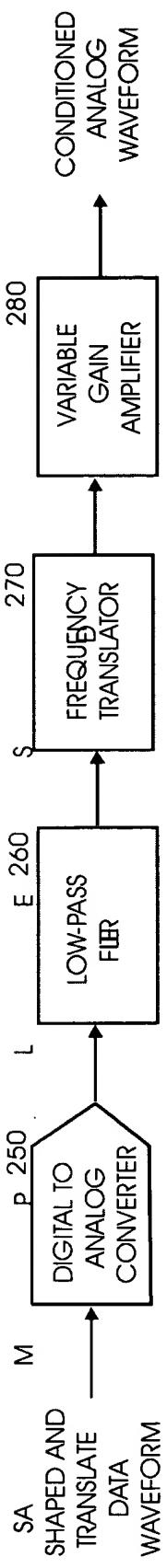
FIGURE 7. ANALOG SIGNAL CONDITIONING BLOCK

SAMPLE

SHAPED AND
TRANSLATE
DATA
WAVEFORM

250 DIGITAL TO ANALOG CONVERTER

260 LOW-PASS FILTER

270 FREQUENCY TRANSLATOR

280 VARIABLE GAIN AMPLIFIER

CONDITIONED
ANALOG
WAVEFORM
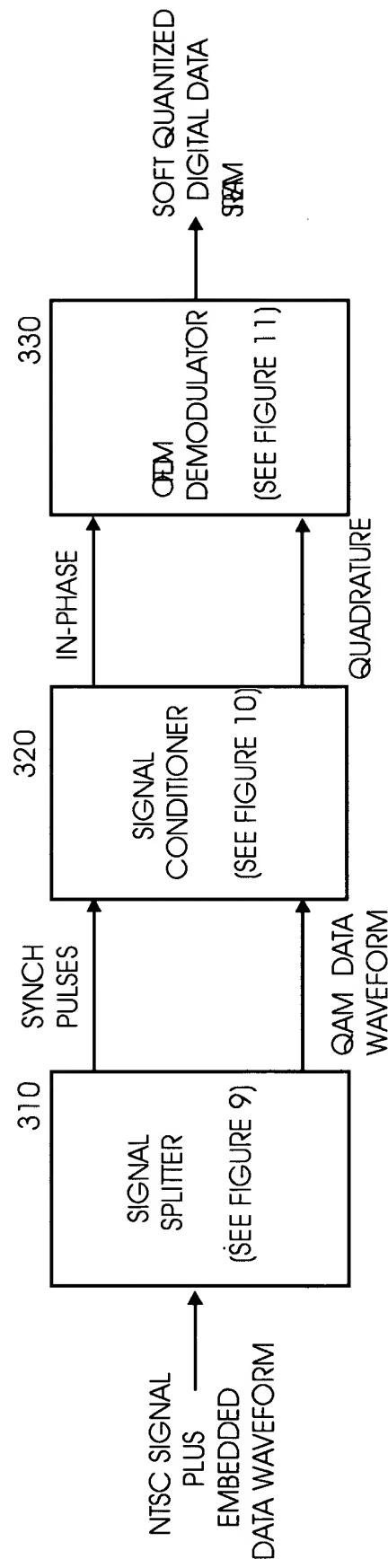
FIGURE 8. DATA DEMODULATOR SIGNAL FLOW

NTSC SIGNAL
PLUS
EMBEDDED
DATA WAVEFORM

310 SIGNAL SPLITTER (SEE FIGURE 9)

SYNCH PULSES

QAM DATA WAVEFORM

320 SIGNAL CONDITIONER (SEE FIGURE 10)

IN-PHASE

QUADRATURE

330 OFDM DEMODULATOR (SEE FIGURE 11)

SOFT QUANTIZED
DIGITAL DATA
STREAM

NTSC SIGNA
PLUS
EMBEDDED
DATA WAVEFORM

410
ANALO
TO DIGITAL
CONVERTER

430
DATA WAVE-SHA
SUPPRESSION
FILTER

L

G

420
NTSC WAVE-SHA
SUPPRESSION
FILTER

DIGITAL DATA
WAVEFORM

440
SYNCH
EXTRACTOR

450
FRAME
SYNCH
EXTRACTOR

NTSC SYNCH
PUL

FIGURE 9. SIGNAL SPLITTER

OFDM
DATA FRAME
BUFFER

495

BINARY DATA
FRAME

IN-PHASE

QUADRATURE

490

FFT FOR OFDM
DEMODULATION

480

CARRIER
RECOVERY
UNIT

475

OFDM
FRAME GATE
AND WINDOW

470

TIMING
RECOVERY
UNIT

NTSC SYNC
PULSES

A    460

FREQUENCY
TRANSLATOR

DIGITAL DATA
WAVEFORM
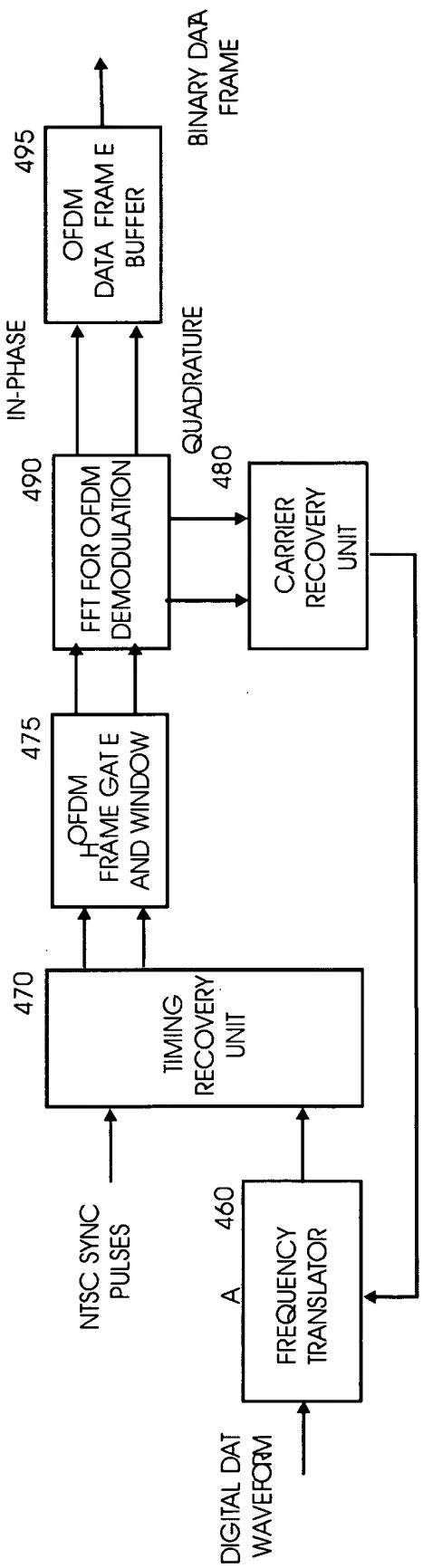
FIGURE 10. SIGNAL DEMODULATOR
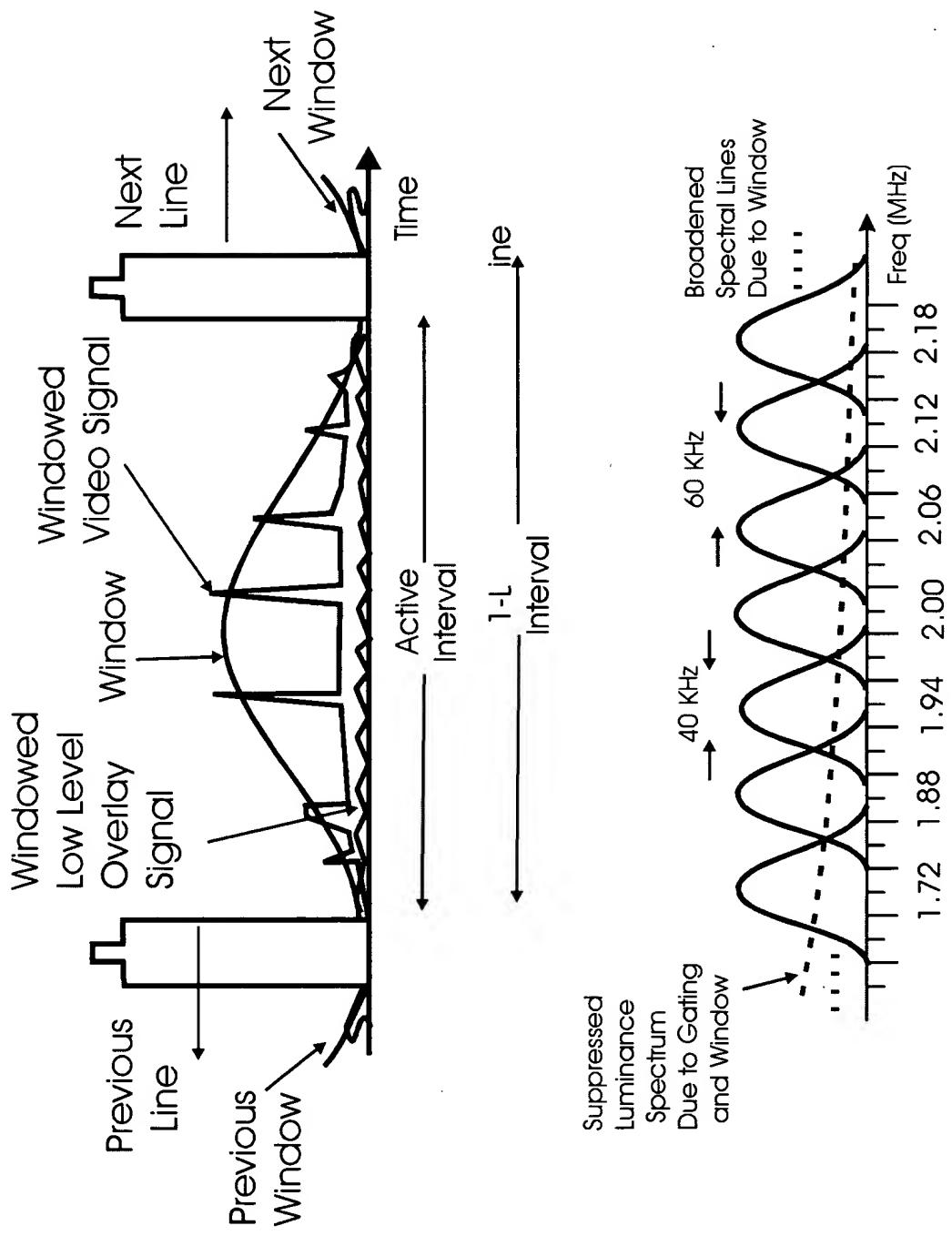
Figure 11: Time and Frequency Domain Effect of Gating and Windowing Active Line Interval Containing Overlaid OFDM Signal
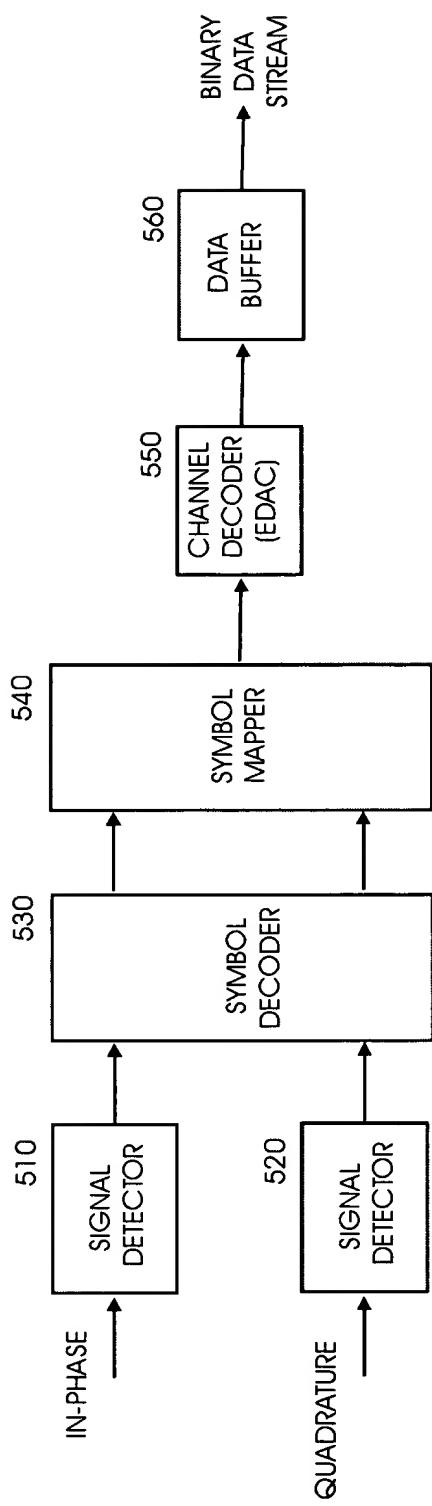
FIGURE 12. DATA DETECTOR AND DECODER

```
┌────────────────────────────────────────────────────────────┐
│                 RECEIVE BINARY DATA STREAM                   │
│                           605                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────┐
│   BUFFER INPUT BINARY DATA STREAM TO SUPPORT INTERMITTENT DATA FLOW   │
│                           610                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────┐
│    EXTRACT VERTICAL AND HORIZONTAL SYNCH PULSES FROM NTSC SIGNAL     │
│                           615                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────┐
│   ENCODE BINARY DATA STREAM WITH FORWARD ERROR CORRECTION CODE      │
│                           620                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────┐
│       GROUP ENCODED BINARY DATA INTO SYMBOL STREAM           │
│                           625                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────┐
│           MAP SYMBOL STREAMS INTO QAM SYMBOL STREAMS         │
│                           630                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────┐
│   NYQUIST SQUARE ROOT FILTER AND SPECTRAL SHAPE QAM SYMBOL ℞M        │
│                           635                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────┐
│           PRE-EQUALIZE SHAPED NYQUIST PULSES FOR            │
│        LATER COMB SUPPRESSION OF NTSC SIGNAL                │
│                           640                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────┐
│  TRANSLATE BASEBAND SIGNAL TO APPROPRIATE SUBCARRIER FREQUENCY       │
│                           645                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────┐
│           CONVERT DIGITAL SAMPLES TO ANALOG SIGNAL          │
│                           650                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────┐
│    FILTER UNDESIRED SPECTRAL COMPONENTS FROM ANALOG SIGNAL  │
│                           655                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌────────────────────────────────────────────────────────────┐
│      COMBINE ANALOG SIGNAL W I T H   I N P U T   N T S C   S I G N A L│
│                           660                                │
└────────────────────────────────────────────────────────────┘
                              │
                              ▼
```

Figure 13. Signal Processing Flow through Modulator
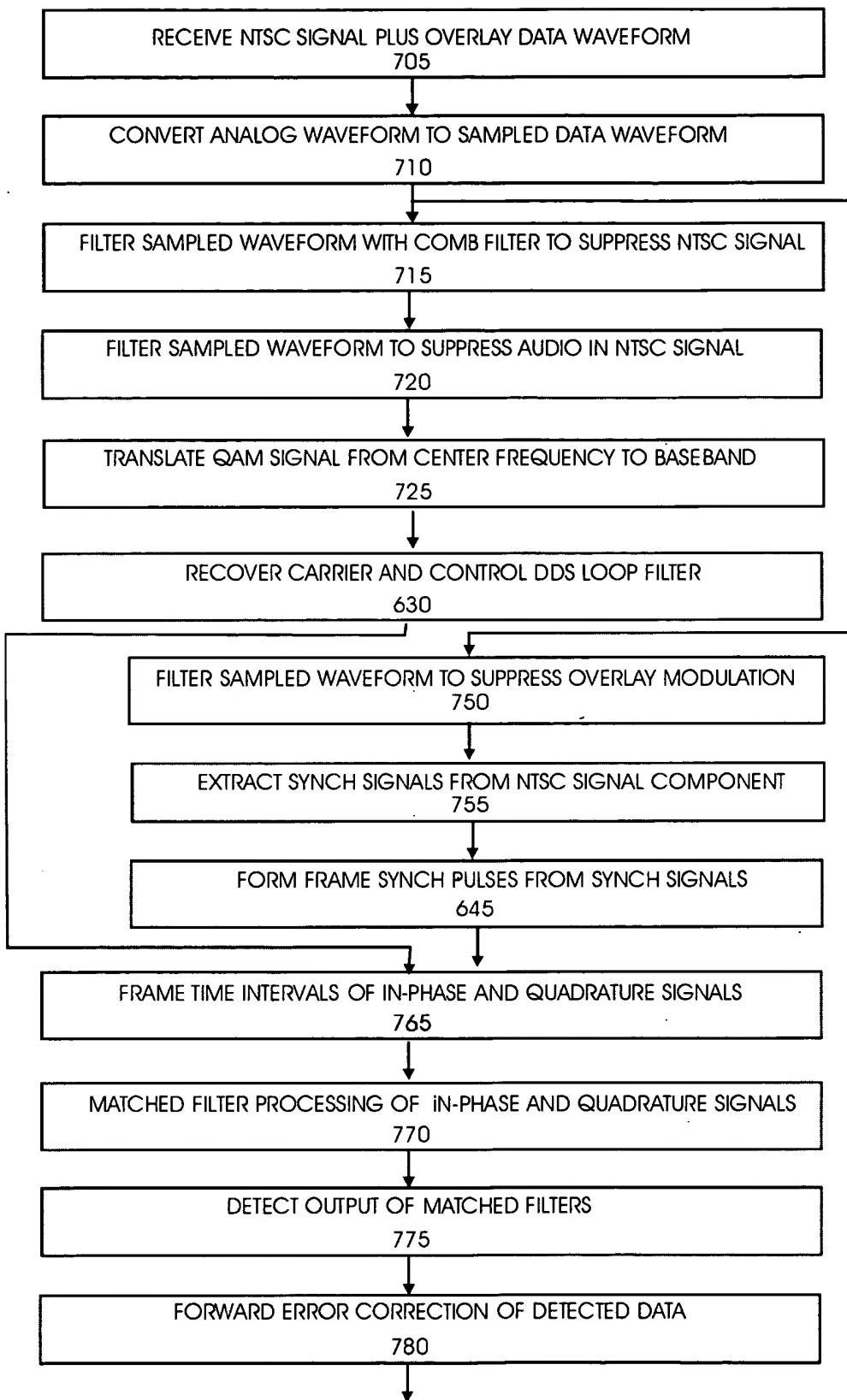
FIGURE 14. Signal Processing Flow Through Demodulator